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MELILOTUS INDICA AS A GREEN MANURE CROP IN SOUTHERN CALIFORNIA*

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Melilotus indica, or bitter clover,[1] will make a satisfactory development during the cool winter months of southern California.

It has outyielded common vetch and Canadian field peas, the two legumes most generally used in the past.

It has increased the yield of the crops following its incorporation in the soil, to a greater extent than any of the other legumes tested.

It is practically immune to aphis injury and will stand more frost than either vetch or peas.

It starts slowly and must be planted not later than October fifteenth if it is to be plowed under by March.

The seed of this clover is now largely a by-product, being separated from the screenings of wheat in which it is often a prevalent weed. It is a heavy seed producer, and should the supply from the above mentioned source be insufficient, it could be grown as a seed crop at a cost much below that of most other clovers.

At the present writing, good recleaned seed can be obtained at from 7 to 10 cents per pound. This makes the seed cost less per acre than vetch or peas.

Per acre, 25 pounds, *M. indica*, at 10c.	$2.50
Per acre, 75 pounds, Common vetch, at 4c.	3.00
Per acre, 100 pounds, Canadian peas, at 4c.	4.00

In the southwest, especially in Arizona and California a yellow flowering annual species of Melilotus is found growing wild under widely differing climatic and soil environments. This species, *Melilotus* indica, has been looked upon as a pest in many sections where it is a prevalent weed in grain fields. Recently, however, this crop has proved to be well adapted for growing in the winter as a green-manuring crop and has been used to a limited extent in the citrus orchards both in California and Arizona.

Melilotus indica is the only one of the three common species of Melilotus that will make a satisfactory winter growth under California

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[1] *Melilotus indica* is variously known as *bitter clover; yellow top, sour clover,* and *sweet clover.* The latter term has been applied so generally to *Melilotus alba* that its use in this connection is confusing. If a commercial term is necessary the name *bitter clover* seems to be the most descriptive of those now in use, since the taste of both seed and stem is decidedly bitter.

conditions. *M. alba* makes a good summer growth and under conditions where the growing of a summer green manure crop is feasible, this sweet clover seems to be superior to cow peas, buckwheat, or soja beans.

During the past winter, 1914–15, *M. indica* was grown to a considerable extent in practically all of the citrus sections of California. Reports have been received from all parts of the state telling of success with this new cover-crop, and the writer has seen heavy tonnages of it produced on most of the soil types common to southern California, from the cobble stone soil of canyon washes to the stiffest of clay adobes.

EXPERIMENTS WITH *M. INDICA* AS A GREEN MANURE CROP

For the past five years, *M. indica* has been tested as a green manure crop at the Citrus Experiment Station and has uniformly given very satisfactory results. From the start this crop gave good tonnages of organic material, and in the yields of the crops following it, marked increases were obtained. In this series of experiments, tenth acre plats were used, there being a total of seventeen plats. On nine plats different legumes were used as winter cover-crops. On every alternate plat a non-legume, rye or barley, was used as a winter cover-crop, these being check plats in comparison with the legumes. All of the green manure crops are sown during September and turned under early in the spring, either in February or in March. Irrigations at monthly intervals are given these crops until the winter rains begin. After plowing under the winter cover-crops on the different plats, various field crops, as potatoes, corn, or sugar beets, are planted over the area as indicators of the comparative value of the different cover-crops as green manures. An equal-sized plat of these field crops is grown on each of the seventeen green manure plats. Uniform cultivations and irrigations are given all plats. At maturity the various crops are harvested, and accurate weighings made of the yields of each plat. In a comparison of these nine legume plats with the cereal plats, the effects on the crop following the incorporation of these green manures were quite varied.

In every case, the crops, following the incorporation of the legumes, gave yields much in excess of those grown after a cereal crop had been turned under. There was also a considerable difference in the effect of the various legumes. The common vetch, *Vicia sativa,* which has been more extensively used for green manuring than any other legume, gave a much less marked increase in yield in the test crops following it than several of the other less common legumes. Taking the non-legume plats as checks, *Melilotus indica,* as a green manure, resulted in an average increase in yield of the test crops following it of 64.8 per cent, while common vetch, *V. sativa,* gave only 28.7 per cent, bur clover, *Medicago denticulata,* 30.4 per cent, and Canadian peas, *Pisum arvense,* 43.3 per cent.[2]

[2] Six different field crops were used in determining these increases, and in all, fifteen crops were averaged in getting the percentages of increase in the yield given here.

In this experiment four of the eight cereal plats had applied to them different amounts of nitrogenous fertilizers in the form of nitrate of soda or dried blood. In one case the application was at the rate of 1092 pounds of nitrate of soda or 1188 pounds of dried blood per acre. The effect of this addition of nitrogen was very noticeable with all the field crops. Even after applying this heavy application of nitrogen in addition to the green manure crop of rye or barley, the average percentage of increase in the field crops following was only 45.6 per cent or fully one-third less than that obtained from the use of a green manure crop of *Melilotus indica* without further nitrogen additions of any sort.

The average tonnage of green tops produced by this melilotus clover has always compared favorably with any of the other crops grown, either legumes or cereals. The root system of this plant, however, is much larger than that of the vetches or peas. A deep tap-root is characteristic of all melilotus clovers, and although this species is an annual, it is no exception in this regard. In fact, six-months-old plants have shown tap-roots penetrating to a depth of eight feet under ordinary orchard conditions.

Most of the orchard soils in southern California have a tendency to form a plow sole or irrigation hardpan. This is commonly considered to be caused in large measure by the frequent cultivations and irrigations. The frequent stirring of the dry pulverized soil, together with frequent applications of water, tends to sift out and wash down the finer clay particles and deposit them in a dense hard layer of varying thickness, just under the cultivated area. Cultivating the soil when it is too wet or too dry tends to change the physical condition of the clay and make this hardpan condition worse. Much can be done toward bettering this condition through proper methods of the cultivations, but even under the best of conditions many of our soils become more or less impervious to water if something is not done to open up this compact layer. Nothing seems to do this as satisfactorily as do roots of rapid-growing, deep-rooted plants. Our experience has shown that the difference in the time necessary to wet the soil to a depth of four feet is very marked between plats having no green-manure crop and those growing each winter a crop of *M. indica* or vetch. For this purpose, M. indica is superior to any of the other winter-growing legumes now available.

TIME, RATE, AND METHOD OF SEEDING

Under orchard conditions in the citrus sections where it is ordinarily thought highly advisable to plow early, that is, during February and March, it is necessary to sow *M. indica* not later than the middle of October if a satisfactory growth is to be had by plowing time. In walnuts and other irrigated, deciduous orchards, where it is considered possible to plow later without injury, the planting of this bitter clover as late as December 15th has given very satisfactory results. The rate of seeding depends upon two factors—the actual area of land planted and the quality of the seed sown.

At present, the seed of *M. indica* is largely obtained from the screenings of wheat, and unless thoroughly recleaned is apt to contain much weed seed and considerable immature seed. Many samples of this seed also show from 5 to 20 per cent of hard seeds which do not germinate the first season. For these reasons the quantity of seed recommended is greater than would be necessary with seed of high quality. The best results have usually followed the sowing of from 20 to 35 pounds of seed per acre, when practically all the land is planted, the amount per acre to be reduced as the trees take up appreciable space. Experience has shown that in most cases much better results are obtained when the seed is sown on the dry soil-mulch before irrigating rather than in the moist soil just after irrigation, as is the common practice with vetches and peas.

The seed is very small and under orchard conditions should be sown broadcast and then lightly cultivated or harrowed into the soil. The irrigation furrows should then be made close enough together to permit of as complete a wetting of the surface as possible. This is necessary if a uniform stand is to be obtained over all the land. Otherwise, much of the seed will not germinate until the rains begin. On very fine sandy soil good results have followed sowing the seed after an irrigation and then cultivating it in while the surface soil is still quite moist. On all other types of soil this method has never given good results.

INOCULATION

All legumes have the power of taking nitrogen from the air indirectly through the bacteria which are naturally present in the nodules on the roots of this group of plants. Under cultivation, however, many such plants are sown on soil new to the plant and in which the necessary species of bacteria may be absent. Most legumes will develop to a fair degree without the assistance of the bacteria, but all grow better with the added supply of nitrogen which these tiny organisms make available to them. When legumes are used as soiling crops, it is necessary to have good inoculation of the plant roots if any considerable amount of nitrogen is to be added to the soil through the decay of these crops. *Melilotus indica* grows wild over much of the state and is in this wild condition naturally well inoculated.

The bacteria that are found in the nodules on the roots of the common bur clover, *Medicago denticulata*, are the same species as that which inoculates the sweet clovers and alfalfa. For this reason, many of our soils do not need further inoculation to grow *Melilotus indica* and to insure the addition of the maximum amount of nitrogen from the air. There are, however, many orchard soils that have been clean cultivated for so long a time that these organisms may not be present in sufficient numbers. On such soils artificial inoculation is desirable.

Directions for inexpensive inoculation are given in Circular No. 87 of this Experiment Station, on "Alfalfa."